To the Commissioner of Patents and Trademarks:

Your petitioners, Michael Van Deurse, a citizen of the United States of America, residing at 14 Smith Street, Norton, MA 02766, whose Post Office Address is Double E Company, Inc., 319 Manley Street, West Bridgewater, MA 02379, William H. Gardner, a citizen of the United States of America, residing at 1833 Broadway, Raynham, MA 02767, whose Post Office Address is Double E Company, Inc., 319 Manley Street, West Bridgewater, MA 02379, and Bryan G. Gousse, a citizen of the United States of America, residing at 6 Forest Street, Winchester, MA 01890, whose Post Office Address is Double E Company, Inc., 319 Manley Street, West Bridgewater, MA 02379, pray that Letters Patent be issued to them for the invention entitled, Composite Expanding Shaft With External Gripping Elements, of which the following is a specification.

Composite Expanding Shaft With External Gripping Elements

CROSS-REFERENCE TO RELATED APPLICATIONS

Applicants claim the priority benefits of U.S. Provisional Patent Application Number 60/406,354, filed 08/26/2002.

BACKGROUND OF THE INVENTION

This invention relates to gripping shafts made from dissimilar materials, and in particular, to carbon fiber reel spools shafts with external gripping elements.

In any process where web material is rewound, be it in the tissue and paper industry or the plastic and film industry, the material is wound onto a core. The core is held on a shaft. Shafts in their simplest configuration consist of either a solid steel shaft with a rotating outer sleeve or steel tubing with journals secured into it. These basic designs are still prevalent and can weigh from 300 to 30,000+ pounds; be 50 to 330 inches long; and 6 to 18 inches in diameter. While durable in design, productivity is limited because the combined weight and length of these shafts limit high speed operations. Since these shafts do not grip the core, they require the use of clamping mechanisms to prevent the core from moving freely along the body, which in turn allows the web material to shift and intermesh with an abutting roll. Web material is normally slit into several rolls before it

is wound onto a core. Lateral movement of the web material causes uneven edges. This leads to handling issues that damage the ends of the cores and the edges of the web material.

Shafts were later developed with the same basic steel design but with the addition of gripping elements. The gripping elements eliminated the need for the use of mechanical stops since the gripping elements exerted enough outward force to hold the core in place. Typically, the gripping elements are activated pneumatically or mechanically, expanding diametrically to grip the core and hold it in place during winding or unwinding of the web material. To allow the shaft to be extracted from the core within the wound roll, air is then released to deflate the gripping elements or the mechanical drive is reversed. This eliminated the need for the operators to secure the core position with clamps or other mechanical devices. The newer shafts address the issue of core position and operator ease but still suffer from the problem of being very heavy and having a limited high speed operation.

Metal shafts have many characteristics which are undesirable, namely, high weight and high rotating inertia. This results in high shaft deflection, high vibration, and premature bearing wear and difficulty with dynamic balance, which causes high driving forces.

SUMMARY OF THE INVENTION

The present invention is the next evolution in gripping shafts. The heavy steel body of prior art shafts is replaced by a base tube material to which are attached manufactured segments of dissimilar material that house pneumatically actuated gripping elements. The base tube material may be a carbon fiber tube, titanium tube, high-grade aluminum tube, steel tube, or any other material that will offer desired physical properties of lighter weight. For example, a shaft made from carbon fiber material rather than metal weighs substantially less (up to 50% less), has a lower rotating inertia (up to 80% less), and high critical speed while maintaining a tube stiffness similar to metal. The main advantage of using dissimilar materials is the ability to optimize the gripping shaft to suit the application, i.e., lighter weight, better wear properties, and strength in appropriate areas. There would not be any benefit to having separate, joinable pieces of the same material.

The present invention affixes to the above described light weight tube manufactured segments such as extrusions of some different material, such as aluminum, titanium, reinforced plastic. Means for gripping the core and thus securing the core's location are provided by pneumatic gripping elements contained within the extrusions. The resultant reduction in weight from prior art devices is significant and allows a user to dramatically

increase web speed while still gripping the core. This ensures that the web material will remain in position relative to the edge of the core. The present invention is most practical with a dead shaft where the journals rotate independent of the body.

In order to have a gripping shaft body that will accommodate the fixed shaft through the inside, the gripping elements are located on the outside. In order to maximize the critical speed of the shaft body, the base shaft tube is made from carbon fiber. The gripping element extrusions are attached to the outside of the carbon tube. In the case of carbon fiber and aluminum extrusions, the extrusions are affixed by mechanical attachment directly into the carbon fiber tube. Depending on what materials comprise the base tube and the housing for the external gripping elements the bonding methods between the two dissimilar materials may include welding, rivets, adhesive bonding, fasteners, integral interlocking shapes, or any other means available to secure two dissimilar materials.

The extrusions which house the external gripping elements are protected from direct contact from the core material by strips or rods which protrude slightly above the extrusion. The strips prevent the core from coming into direct contact with the extrusions. The strips are made from a material which has high strength and good wear characteristics. Materials such as ultra-high molecular weight polymers are preferred because they have

excellent wear properties, are light weight and easily manufactured. The wear strips may be affixed directly to the base tube in the same manner as the extrusions or can be integrated directly into the extrusions. The wear strips are preferably modular in design and easily replaceable as they are a wear item and over time will need to be replaced. The wear strips are positioned between each of the external gripping elements and also provide the shaft with a consistent external diameter. Because of their low coefficient of friction they also aid in the installation and removal of spent and new cores.

The gripping elements may be made from a wide variety of materials, including steel, silicone, rubber, etc. The selection of a proper material is application dependent. Preferably, the gripping elements are retractable back into the extrusion so that the shaft can be easily extracted from the core. In one preferred embodiment, the gripping elements, which are comprised of small rubber bladder tubes, are independently expanded with air through a manifold used to both deliver air to the bladders and vent the bladders. Each bladder acts independently of the other, thereby ensuring the loss of only one gripping element if there is a bladder failure and air pressure is lost in that particular bladder. The remaining gripping elements will continue to hold the core securely.

The invention, therefore, is a light weight base tube, preferably a filament wound carbon fiber composite tube, with external extrusions of a dissimilar material, preferably aluminum, which house gripping elements and wear strips, all affixed to the base tube. The wear strips are preferably made from ultra high molecular weight polymer. The base tube replaces a prior art metal bodied dead shaft. The present invention permits end users to retain their current shafts along with all of their bearings. The present invention replaces end users' prior art outer shell with a light weight composite shaft with gripping elements. Since the present invention has its gripping elements attached to the outside of the base tube, end users are not required to change core size and thus can reuse all of their internal components. The present invention may also be used in a shaft with affixed journals.

The present invention overcomes two of the biggest problems with the traditional shaft, i.e., weight and the ability to grip the core. By utilizing carbon fiber in the body of the shaft, the weight is dramatically reduced and, therefore, the critical speed is increased allowing an increase in the operational speed of the shaft. The weight reduction for any given design may be more than 50%. The end user realizes further gains in productivity, as the operators no longer have to attach clamping collars and secure the core in place. The user simply inflates the shaft, and the external gripping elements grip the inside of the core. In the

case of the dead shaft, the present invention allows end users to retain their original axle and bearing assemblies and reuse them. The external gripping elements and wear strips allow for easy preventative maintenance on the only wear items in the shaft, and the modular design ensures that replacement parts will be easily installed and stocked. The same argument exists for a live shaft reel spool, where the journals rotate with the shaft housing.

These together with other objects of the invention, along with various features of novelty which characterize the invention, are pointed out with particularity in this disclosure. For a better understanding of the invention, its operating advantages and the specific objects attained by its uses, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side elevational view of a shaft constructed according to the principles of the invention.

Fig. 2A is a cross section view along the line B-B of Fig. 1.

Fig. 2B is close up view of Detail "B" of Fig. 2A

Fig. 3 is a cross section view along the line C-C of Fig. 1.

Fig. 4 is a cross section view along the line D-D of Fig. 1.

Fig. 5 is a close up view of Detail "C" of Fig. 1.

Fig. 6 is a close of view of Detail "A" of Fig. 1.

Fig. 7 is a cross sectional view of a longitudinal rail.

Fig. 8 is a close up view of a fill and vent valve.

DETAILED DESCRIPTION OF INVENTION

Referring to the drawings in detail wherein like elements are indicated by like numerals, there is shown a gripping shaft **1** constructed according to the principles of the present invention. The shaft **1** has an elongated cylindrical body **2** with two, opposite end portions **3**, said end portions defining a longitudinal axis of the shaft **1**. A portion of the elongated body between the opposite end portions **3** is termed the intermediate body portion **4**. The shaft **1** is comprised of a generally cylindrical carbon fiber tube **10** having an internal wall **11** and an external wall **12**, and two opposite ends **13** joining the shaft end portions **3**, said opposite ends **13** and shaft end portions **3** defining the tube **10** and shaft **1** longitudinal axis. The tube external wall **12** has twelve elongated, parallel, aluminum, longitudinal rails **20** attached thereto and forming, in conjunction with fiber tube **10**, the shaft intermediate body portion **4**. The rails **20** are attached radially to the tube external wall **12** and lay in longitudinal planes parallel to the tube and shaft longitudinal axes. The rails **20**

are equally spaced about the tube external wall **12**. Other embodiments of the invention could have a different number of rails **20** and could be made from a material different from aluminum but with substantially similar properties and characteristics. The individual rails **20** assembled circumferentially create a cylindrical profile termed the gripping shaft outer diameter **5**. The rails **20** are attached to the tube external wall **12** by mechanical means as described below.

To accommodate journals, other driving hardware and the like at the shaft ends, the shaft end portions **3** each have a protective end external steel sleeve **30** positioned about and joined to the carbon fiber tube external wall **12**. The protective end external steel sleeve **30** has an inner surface **31** and an outer surface **32**. The protective ends **30** provide a connection point for the tube **10** and a truncation location for individual rails **20**. The protective ends **30** are preferably made using a material exhibiting properties such as high wear resistance, high impact and shock resistance, and dimensional stability.

The gripping shaft **1** is further comprised of an inner steel sleeve **40**, having an inner surface **41** and an outer surface **42**, positioned within and joined to the carbon fiber tube internal wall **11** beginning approximately at the junction between shaft intermediate portion **4** and shaft end portion **3** and extending toward the shaft end a predetermined distance. In order to

accommodate customer bearings, the inner steel sleeve **40** does not extend to the end of the shaft. The inner steel sleeve **40** may be secured to the tube **10** by mechanical fasteners, bonded connection or an interference press fit.

The tube **10** may be manufactured from any light weight, high stiffness material, provided that it has dissimilar properties from the rails **20**. Desirable tube properties include low inertia, high resistance to torsional deflection and high bending stiffness. The present embodiment of the invention utilizes a carbon fiber composite which may be manufactured by filament winding, pultrusion, hand lay-up or roll table wrapping.

As may be seen most clearly in Fig. 7 illustrating a cross sectional view of a rail **20**, each rail has an inner surface **21** and an outer surface **22**. The rail inner surface **21** matches tangentially the tube external wall **12**. The rails **20** are secured to the tube external wall **12** in a captive manner while allowing longitudinal expansion and contraction due to temperature or operational changes. In one embodiment of the invention, the rails **20** are attached to the tube **10** utilizing a threaded fastener connection with slotted holes **28** in the rails **20**. The present invention positions these holes **28** in an alternative fashion longitudinally. The rails **20** encompass three critical components integral to the invention, i.e., gripping elements **50** and their respective components, sliding strips **26**, and rotational balance

correction weights. The rail outer surface **22** has two longitudinal channels, a first channel **23** and a second channel **24**. The second channel **24** has a subchannel **25** formed therein. The channels **23**, **24** and subchannel **25** all use an interlocking design to help secure their contents.

The subchannel **25** provides means for holding and positioning weights for balancing the gripping shaft **1**. Balance correction may include, but is not limited to, custom flat bar stock or suitable weight inserted into the subchannel **25** and secured by a central fastener or permanent bonding/adhesion. The second channel **24** provides means for holding sliding strips **26** which protrude slightly above the rail outer surface **22**. The sliding strips **26** prevent a core from coming into direct contact with the rails **20**. The strips **26** are made from a material which has high strength and good wear characteristics. Materials such as ultra-high molecular weight polymers are preferred because they have excellent wear properties, are light weight and easily manufactured, but equivalent materials such as Nylon, Acetal, or the like, may be used. The sliding strips **26** are preferably modular in design and easily replaceable as they are a wear item and over time will need to be replaced. The sliding strips **26** are positioned between each of the external gripping elements **50** and also provide the gripping shaft **1** with a consistent external diameter. Because of their low coefficient of friction they also

aid in the installation and removal of spent and new cores.

The rail first channel **23** contains a gripping element **50** comprised of: an elongated expandable pneumatic bladder **51**; two elongated, protective polymer strips **52**, such as that sold under the trademark MYLAR, placed under and over the bladder **51**; an elongated rubber gripping element **53** placed over the outer polymer strip **52**. As the bladders **51** are pneumatically activated and expanded, the gripping elements **53** move radially outward thereby engaging a core. The protective ends **30** have longitudinal channels **33** formed therein corresponding to the rail first channel **23**. The gripping elements **50** continue through the protective end channels **33** and terminate near to the gripping shaft end portions **3**. One end of the gripping elements **50** terminates in a valve assembly **54** interconnected to an air manifold **55**.

Unlike prior art gripping shafts, the present invention incorporates a combination of dissimilar components assembled in a manner that exhibits enhanced characteristics. In the present invention, a carbon fiber tube **10** is mated with an inner steel sleeve **40**, steel protective ends **30**, and aluminum longitudinal rails **20** containing ultra-high molecular weight sliding strips **26** and rubber gripping elements **50**. This combination provides an increased load carrying capacity, higher bending stiffness, low weight and low inertia.

In one specific embodiment of the invention, the gripping shaft **1** was constructed of a filament wound tube **10**, twelve aluminum longitudinal rails **20**, and two protective steel ends **30**. The filament wound tube **10** was created on a 12.03 inch diameter mandrel and was ground to a finish diameter of 14 inches. The length was machined to 236.5 inches. The protective ends **30** were machined to approximately a 14 inch inner diameter nominal with an outer diameter of 15.95 inches nominal. Insertion of the tube **10** to the protective ends **30** was 14 inches and was secured internally using a 12.03 inch outer diameter machined inner sleeve **40**. Aluminum longitudinal rails **20** were made using an extrusion process with an approximate cross sectional width of 4 inches and a height of 1 inch. The inner and outer surface is curved to 14 inches diameter and 15.96 inches diameter, respectively. The twelve longitudinal rails **20** are positioned radially (every 30 degrees) and secured to the tube **10** using fasteners.

It is understood that the above-described embodiment is merely illustrative of the application. Other embodiments may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.